Microwave Kinetic Inductance Detectors for UVOIR and X-ray Astrophysics

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The Hubble Space Telescope, and more than four decades of improvements at ground-based observatories, has proven that **detectors** are the drivers of new discovery in Astrophysics. Improving our detectors is far more cost effective than building larger telescopes, and provides the surest path to fundamental discoveries awaiting us over the next 30 years.

Microwave Kinetic Inductance Detectors (MKIDs) are NASA-funded cryogenic detectors capable of detecting single photons and measuring their energy without filters or gratings, like an X-ray microcalorimeter. They are useful across the electromagnetic spectrum, but here we focus on UV, optical, and near-IR (UVOIR) and X-ray MKIDs. Current state-of-the-art UVOIR MKIDs feature array sizes in the 2-10 kilopixel range, energy resolution $R=E/\Delta E\sim16$ at 254 nm, and quantum efficiency that goes from 70% in the UV to 25% in the near-IR[1]. Future improvements should significantly improve this already impressive performance. An example of one of these arrays is shown in Figure 1. X-ray MKIDs with state of the art energy resolution and >10 kilopixel formats are also under development. UVOIR detectors are a top priority for the Cosmic Origins Program (TCOP), with high QE UV detectors, photon counting UV detectors, and photon counting visible/IR detectors called out as three of the highest priority goals in the 2012 Cosmic Origins Program Annual Technology Report. MKIDs are all three of these detectors at the same time, with the added bonus of intrinsic energy resolution, microsecond time resolution, no read noise or dark current, and nearly perfect cosmic ray rejection. The large format, high-resolution X-ray arrays that are a top priority for the Physics of the Cosmos (TPCOS) program can be made with MKIDs.

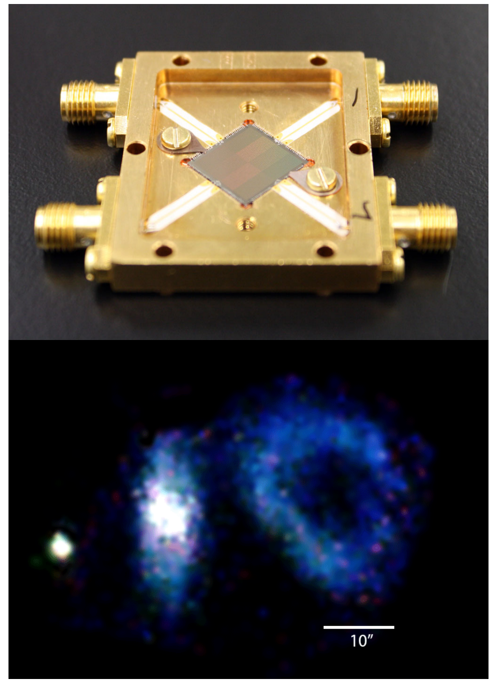

Figure 1. Top: A photograph of a 2024 pixel UVOIR MKID array (with microlens removed for clarity) in a microwave package. Bottom: A mosaic of Arp 147 (a pair of interacting galaxies) taken with the MKID array shown in the top panel. The image was taken with the ARCONS instrument in December 2012 at the Palomar 200" telescope.

MKIDs have the potential to revolutionize astronomy. The leap in capabilities from a semiconductor-based detector to a MKID is similar to the leap from photographic plates to CCDs. Over the next thirty years, MKIDs will grow from small kilopixel imaging arrays into powerful, Megapixel arrays used in a variety of ground and space-based instruments, from deep ~50 color imagers, to planet finding integral field units (IFUs), to order sorters for high resolution echelle spectrographs. Increased investment in this technology will pay significant dividends for NASA's future astrophysics endeavors.

[1] B.A. Mazin, B. Bumble, S.R. Meeker, K. O'Brien, S. McHugh, and E. Langman. A superconducting focal plane array for ultraviolet, optical, and near-infrared astrophysics. Optics Express, 20(2):1503–1511, 2012.